The elements necessary to assemble broadband services using ADSL for broadband access are identified below. In addition to those specified by the FCC, the set contains UNEs that are associated with ADSL-equipped loops and allow CLECs suitable access to such loops. We emphasize that this is only a potential set, since CLECs may not require all of the forms of interconnection these would allow. For instance, since the copper pairs needed for xDSL already terminate in a Network Interface Device, and given that there appears to be a growing popularity of "splitterless" ADSL, demand for the first two elements below may not materialize.

Network Interface Device (NID): The NID forms the point of demarcation between the ILEC network and the customer's inside wiring. It provides a simple connection, typically using an RJ-11 jack specified in the FCC Part 68 Registration Rules, between the drop and the premises wiring, as well as appropriate lightning protection. NIDs, with suitable additions of modular internal components, can typically can support several lines at one location.

NID-mounted splitter: This device, whose use in various forms of ADSL is described in the Appendix, may be added to an existing NID to separate the ADSL data signal spectrum from the voiceband spectrum. It may be required for so-called "full-rate" ADSL, but it is not necessary for "splitterless" ADSL. A subscriber who elects to subscribe to a form of ADSL requiring a splitter at the customer's premises, and whose network interface predates the "modular" NID described in the Appendix, however, will apparently require the installation of a NID equipped with the splitter.

Distribution facility: In conventional local telephone networks, the distribution facility for residential telephone service consists of the drop wire pair that connects with the NID, the block terminal connecting the drop pair to the distribution cable pair, and the distribution cable pair that extends to the feeder/distribution interface. xDSL technologies are designed to operate over such conventional distribution facilities with the addition of the broadband terminals (ATU-R and ATU-C, or DSLAM, in the case of ADSL) at the two ends, subject to the distance and other constraints described in the Appendix.

Feeder/distribution interface: The feeder/distribution interface ("FDI") provides the connection between the distribution cable pair for a given loop and the feeder facility. In the case of all-copper loops, the feeder/distribution interface consists of a cross-connection device, such as a Serving Area Interface, that allows the distribution cable pair to be connected electrically to a corresponding feeder cable pair. For loops served with digital loop carrier equipment, the feeder/distribution interface includes a DLC RT in addition to the cross-connection device that allows the distribution cable pair to be connected to a channel unit input in the RT. What the CLECs require in this case is the ability to locate their equipment in the FDI, including, to the extent they are technically feasible and are available in the marketplace, xDSL plug-in cards for the DLC RT.

Feeder facility: In an all-copper, non-multiplexed, loop, the feeder facility consists of a pair of wires that extends from the feeder/distribution interface to the main distributing frame ("MDF") in the CO, and includes the protection block in the MDF. In a DLC-fed loop, the DLC feeder facility is an optical fiber loop transport system that carries time-division-multiplexed signals from the RT to an optical transmission terminal (multiplexer) in the CO. In a non-concentrated DLC system, each subscriber voice signal "appears" in the multiplexed bit stream carried by the fibers in the feeder cable as a separate DS-0 (64 kbps) signal. In a concentrated DLC system, there are fewer DS0s in the feeder bit stream than there are subscriber loops, as DS-0 time slots are assigned to subscribers on a demand basis.

Bandwidth enhancement device: This device contains the DSLAM function. In the case of all-copper loops, it resides in the CO. For DLC-served loops, it exists either as a plug-in card in the RT itself (if the RT supports ADSL channel units), in a shelf within the RT enclosure, or in a cabinet collocated with the RT.

xDSL loop transport (DLC cases only): This element addresses the additional bandwidth in the loop transport facility required to transport the data components of the xDSL signal. It applies only to loops using transport multiplexing, such as those supported by DLC systems using fiber feeder cable.[87] It includes multiplexing costs to support the added bandwidth requirements.[88]

Broadband signal grooming: This element separates data streams from the DSLAM output for routing to multiple service providers. It is required when a common set of DSLAMs serves customers subscribing to different data service providers. This includes the case in which the DSLAMs are located in DLC remote terminal channel units and multiple service providers purchase unbundled elements at the RT level, leading to intermingled data streams in the loop transport facility. The grooming function is not required when an array of DSLAMs handle customers served by a single service provider

---

[87] DLC using copper feeder, while technically possible, is not practical for ADSL applications because of the inordinate number of wire pairs that would be required.

[88] The technology used for loop transport ADSL multiplexing should not be at issue here. In some cases, it will be time-division multiplexing and hence use part of an existing SONET payload (e.g., OC-3c signals contained in an overall OC-12 payload which also carries the narrowband TDM information). In other cases, the ADSL signals may be carried on a dedicated optical carrier multiplexed onto the DLC fibers using some form of wavelength-division multiplexing.

or when ADSL data streams generated by DLC-served customers have been time-division or optically multiplexed.

Broadband switching: This element applies to packet switching/routing functions provided between the bandwidth enhancement element and the interoffice transport system.

Broadband interoffice transport: This element is essentially for transport of the broadband data signal from the CO to the CLEC POI. It includes a multiplexing function in the CO to combine the signals from multiple customers. Transmission rates will generally be DS3 or higher SONET rates.

5. In addition to, or in lieu of, unbundled network elements, the requirement to provide unbundled broadband network access can be specified in terms of particular access configurations.

Rather than dealing only in terms of UNEs, it is useful to also define CLEC requirements in terms of different combinations of network elements, where each such combination provides a useful segment of the broadband network to the CLEC, and the interface at each of its ends can be readily specified through existing standards and/or the specifications of network vendors who provide the elements adjacent to the interfaces.

Figures 1, 2a, and 2b show a number of interfaces to the BLEN, labeled with arrows lettered A through F.[89] The interface points are as follows:

- Interface A: CLEC POI, at the point where the ILEC transmission facility meets the CLEC facility
- Interface B: point of connection between the broadband switch and the interoffice transmission terminal, which, as Figure 1 intends to show, may either be in the CO or at the switch hub;

[89] In Figure 1, the interface points B and C in parentheses are intended to point towards the Switch Hub.

- Interface C: point of connection between the equipment that terminates the broadband access system (the DSLAM, in the case of ADSL, as seen in Figures 2a and 2b) and the broadband switch, which again can be at either the CO or switch hub;[90]
- Interface D: end of the broadband access medium, which, for ADSL on copper wires, occurs at the splitter (Figure 2a), and for ADSL on DLC, occurs at the SONET multiplexer in the FDI or CO (Figure 2b);[91]
- Interface E: customer side of the NID, which for ADSL occurs at the splitter on the customers' premises, if there is a separate splitter; and
- Interface F: customer side of the access termination, which for ADSL is the ATU-R.

In terms of these interfaces, the end-to-end broadband connection specified in the second principle terminates in Interfaces A and F in Figure 1. Other network segments can be defined as the portion of the network located between two of the interface points. There are some obvious candidates that would be of interest to CLECs. A few examples follow by way of illustration; the most useful configurations can be identified and specified as the CLEC requirements become clear and additional interface specifications become available:

<u>Data-capable access</u>: Data-capable wire pair from premises to CO that can support, but has not been configured for, broadband transmission, without requiring special treatment such as conditioning.[92] This configuration corresponds to the segment between Interfaces D and E in Figure 2a.

<u>Data- equipped access</u>: Technology-independent premises-to-CO link that supplies a per-subscriber data signal at various data rates through a broadband transmission interface at

---

[90] When Interface C is at the switch hub, the interface is literally between the access trunk, as we have defined it, and the switch.

[91] The signal on the "outside" of the SONET multiplexer pair should be the same in the FDI and RT;

the CO. Transmission may be supported over a premises-to-CO copper pair equipped with the DSLAM in the CO, a copper pair and fiber DLC system with the DSLAM located at the RT and appropriate ADSL loop transport, another member of the xDSL family, a wireless loop system, or any other suitable technology capable of supporting the required bandwidth for digital data transmission. This configuration corresponds to the segment between Interfaces C and F in any of the figures.

Access Trunk: the network segment between Interfaces A and C, providing a CLEC that is not collocated with the ability to access its customers' data streams on the network side of the broadband access system.

Concerning the last of these configurations, when the ILEC chooses to consolidate its edge switches in a switch hub, the CLEC should not be required to pay for the access trunk from the CO to the Switch Hub, but only from the CO or Switch Hub to its own POI.

6. The CLECs should be able to collocate transmission equipment and broadband switches in the CO, Switch Hub, or both, depending on the location of the ILEC broadband switch.

If the Interfaces labeled B, C, and D are to be meaningful, the CLECs need to be able to collocate transmission equipment in the CO and/or Switch Hub in order to be able to transport their broadband signals to their own POIs. Lacking that ability, they will have to rely on ILEC interoffice transport offerings; if that occurs, they will have purchased so much of the ILEC's local exchange network that it will be difficult for them

[92] For conventional copper loops, this means that any loading coils are removed, and bridged taps are also removed, at least to the extent that the total tap distance exceeds prescribed requirements for the data transmission technology to be used, e.g., ADSL.

to compete with the ILECs for local exchange services. In addition, given the broadband nature of the data signals from the subscribers, and the bursty nature of many forms of broadband communications, there may be a substantial reduction in the required bit rate coming out of the broadband switch compared to the aggregate bandwidth of the signals going <u>into</u> it. Therefore, collocating their broadband switches as close to the CO end of the broadband access facility may substantially reduce the required bandwidth of the interoffice transport facility, whether their own or an unbundled ILEC offering. ILEC collocation requirements were discussed previously in Section IV.

7. <u>ILEC broadband offerings should not be allowed to bind broadband access to a particular ISP, thereby lessening or eliminating the role of the CLECs in carrying Internet traffic. Connections to ISPs should be switched connections.</u>

Most current ILEC ADSL offerings use ATM as the broadband switching technology. ATM protocols have been defined with sufficient flexibility to provide subscribers with a true switched service -- that is, where subscribers can set up one or more connections across an ATM network through a connection establishment process that assigns a circuit identifier to each connection. The user can then send data over each established connection by inserting the appropriate connection identifier in the cell's address field. Unfortunately, while data to and from a subscriber's premises over ADSL is structured into ATM cells, the ILECs have generally not implemented <u>switched</u> ATM service. Instead, at the time subscribers order ADSL service, they must also designate the ISPs from whom they wish to receive service. All data to/from the subscriber is then "hard wired" to that particular ISP through the ATM switch. Inasmuch as we have included switched transport in the definition of broadband services, the current ADSL offerings hardly qualify as broadband offerings. The significance of this is that the

ILEC's underlying ATM data service is tightly coupled with the services of a particular ISP. This provides an ILEC the opportunity to preferentially sell its own ISP service. Moreover, it essentially precludes any role a non-ISP CLEC can play in providing a competitive broadband local exchange service. This does not comport with the goal of creating a robust competition for such services.

8. To the extent the broadband access technology can jointly support voice and broadband data services, as is the case with ADSL, subscribers should be able to separately designate which entity provides its voice and broadband data service. Given that designation, the CLECs should not be forced into an inefficient arrangement for providing either or both services.

In ADSL, and possibly other broadband access technologies, the output of the broadband transmission system for a given subscriber includes analog or 64 kbps digitized voice signals that are separate from the data signals. The question then arises as to the proper disposition of the voice signal. The goal of promoting competition in the local exchange will best be served if the Commission adopts the following principles for determining the providers of voice and broadband data services.

First, the CLECs should be able to provide broadband data only: they should not be required to provide voice service in order to enter the broadband services marketplace simply because the access technology enables the joint provision. On the other hand, they should be free to enter the voice marketplace as well if they choose to do so.

Second, if a CLEC's potential broadband data customer is currently receiving voice service from the ILEC on an ADSL-capable loop, and the subscriber opts to continue to receive its voice service from the ILEC, the CLEC should be able to provide the broadband data service to the customer by purchasing the unbundled ADSL data capability from the ILEC and/or by installing its own ADSL equipment on the loop. In no case should the CLEC be forced to purchase a separate loop to the ADSL-capable customer in order to provide ADSL service, although it may choose to do so.

Third, if the customer chooses to receive both the voice and broadband data services a CLEC may choose to offer, the CLEC should be able to purchase an unbundled loop that is ADSL-capable, and install the ADSL equipment necessary to provide both services to the customer. If a customer's loop is not currently ADSL-capable, but other ADSL-capable loops are available and can feasibly be used to provide ADSL service to that customer, the ILEC should, with appropriate compensation, move the customer to the ADSL-equipped loop, equip the loop with ADSL (or allow the CLEC to equip it), and provide the data signal, or both voice and data signals, to the CLEC, depending on the subscriber's choice of voice providers.

9. The Commission should adopt requirements that promote the non-discriminatory provision of network access by the ILECs to the CLECs. To the extent that such access requires technical interface specifications, the Commission should adopt principles that ensure the timely development of such specifications.

For the CLECs to achieve efficient access to the ILEC BLEN at the various interface points identified previously, even on an end-to-end basis, the technical attributes of the various interfaces in question must be specified. At a time when the broadband technologies are embryonic and still evolving, it would appear to be difficult to precisely specify the characteristics in a way that will stand the test of time. Furthermore, some specifications are always likely to be vendor specific, such as the type of plug-in cards to be installed in a particular vendor's DLC RT.

At the same time, certain commonalities are appearing in the technology offerings of different broadband vendors, and thus in the service offerings of the various ILECs.

These include, for instance, the data communication protocols used within the broadband switch and appearing at the subscribers' premises and at the CLEC POIs or ISP POPs, the nature of the modulation used to combine the voice and broadband data signals over ADSL-equipped loops, and the types of SONET data formats used in interoffice transport.

Due to the intensity of the competition between broadband equipment vendors, a tremendous amount of literature is available from these vendors. Also, the purchasers of broadband equipment are putting a substantial amount of pressure on the vendors to comply with both formal standards and informal agreements hammered out in industry forums. To the extent the vendor offerings comply with those standards and agreements, the publications of those bodies also provide a rich source of information. Even older standards can help: for instance the safety portion of Bellcore's New Equipment-Building Specification provides useful safety standards for collocation.

Given the ferment described above, it is unlikely that the Commission could, or should, attempt to set industrial policy by selecting among the various broadband technologies that are available. Instead, the Commission should seek to adopt rules that will facilitate the resolution of technical interface issues and lead to a timely specification of these interfaces. A possible set of principles that might guide it in this effort is as follows.

First, the Commission should identify which interfaces, unbundled network elements, and network configurations are to be made available to the CLECs. In making this determination, it should take into consideration the CLECs' needs for different forms of access, the technical feasibility of such access modes, and the availability of working versions of an interface specification.

Second, the Commission should adopt stringent network disclosure rules that require each ILEC to specify the technical characteristics of the modes of interconnection it will provide, the timeframe when these modes will initially be available, and their detailed deployment plans, all in a fashion that is non-discriminatory in the ILEC's treatment of its own subsidiary. Third, the Commission should institute a process for the ILECs to provide detailed reports on the interfaces they currently support, which the FCC can assemble into a nationwide report. These reports should reference specific literature provided by vendors, standards bodies, and industry forums that accurately describe the interfaces the ILECs will actually provide. Fourth, where there are gaps in the existing specifications, the FCC should seek to determine which, if any, bodies are currently working to fill the gaps. To the extent this identifies any gaps that are not being addressed, the Commission could institute a technical forum with carefully-identified, prioritized, and focused goals. Finally, the Commission should encourage and monitor efforts for the ILECs and the CLECs to develop interface agreements on an individual case basis, again seeking to ensure that such agreements are non-discriminatory in the treatment of their own subsidiary.

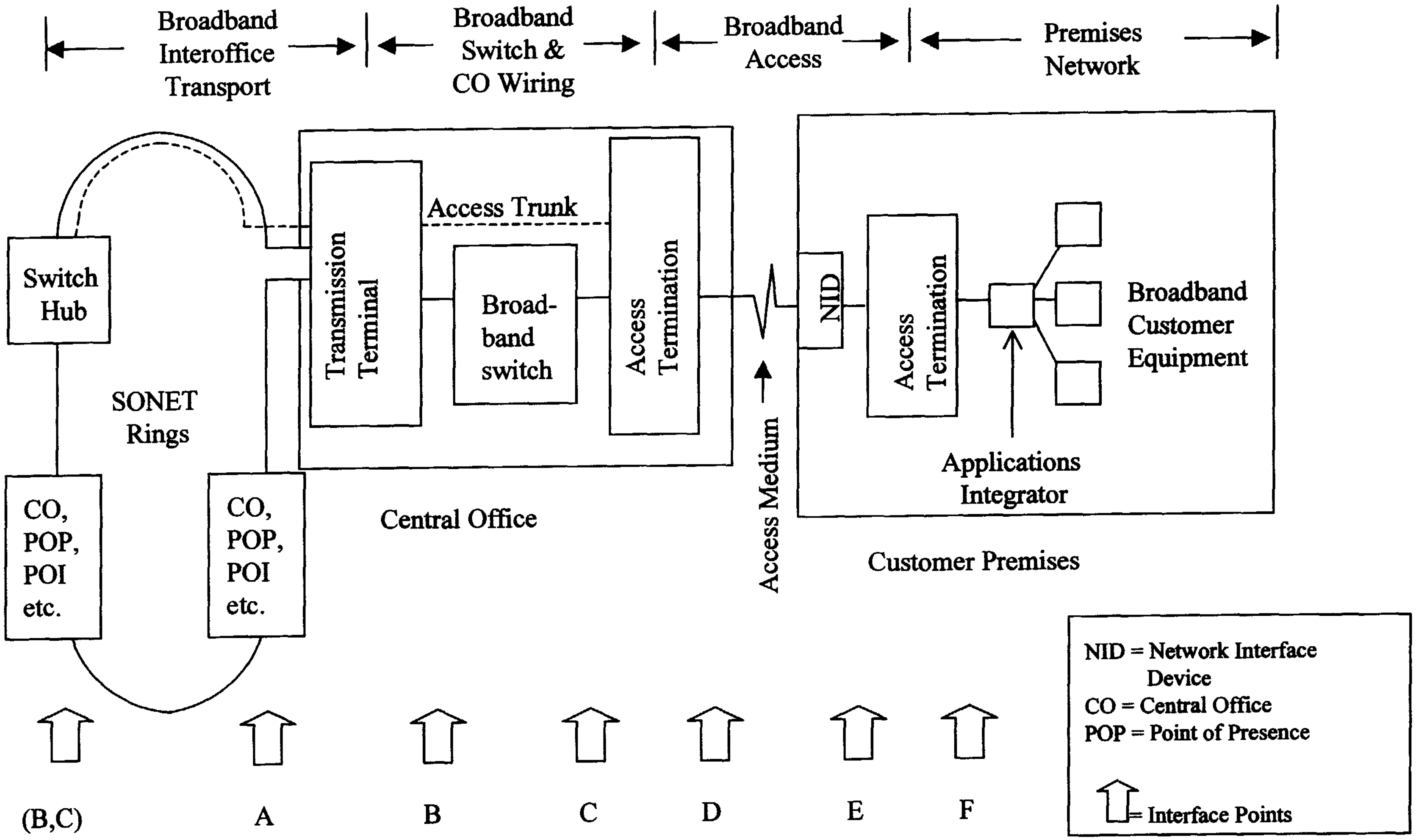
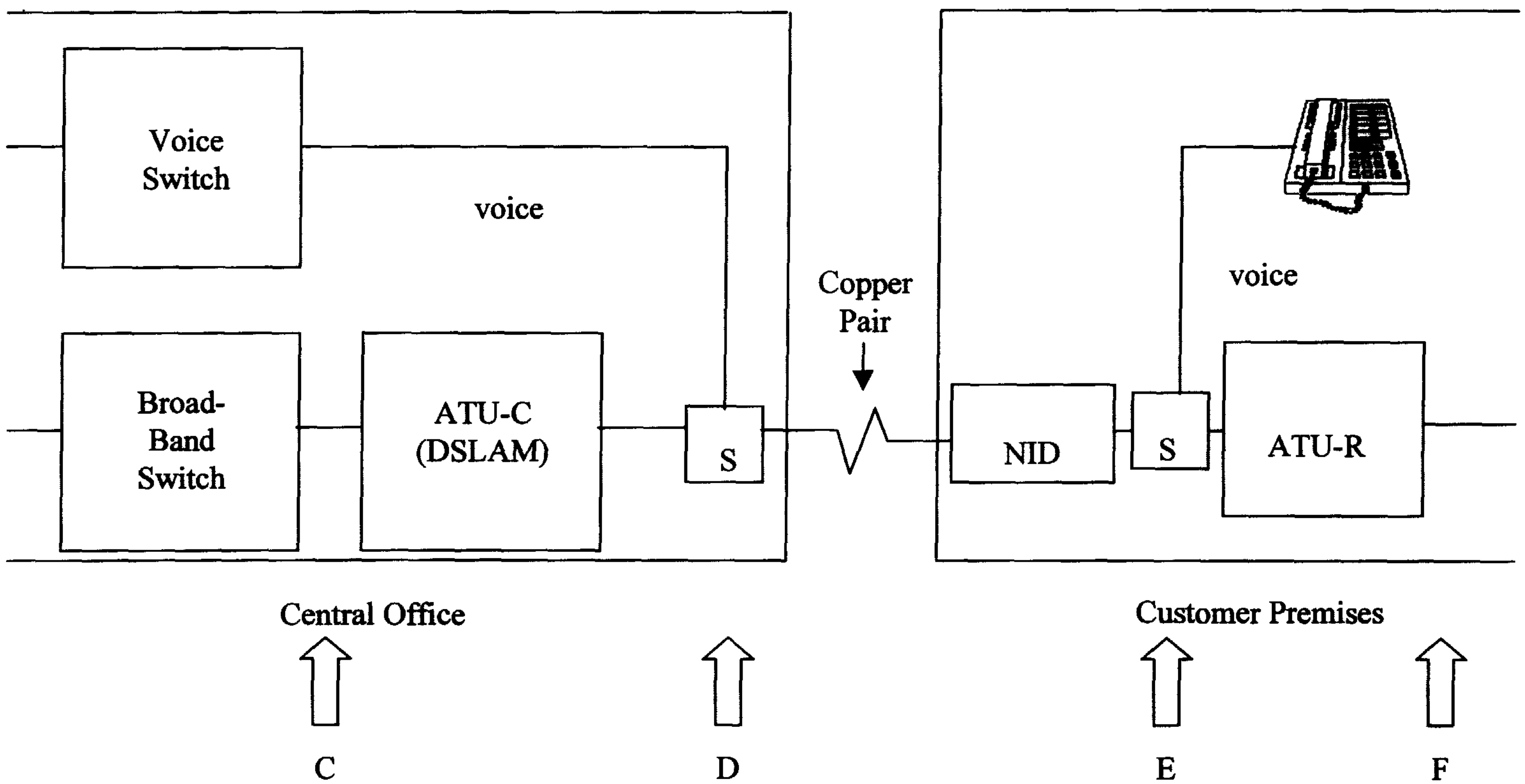



**Figure 1: Components of the Broadband Local Exchange Network**




S = Splitter
ATU-C = ADSL Terminal Unit- Central Office
ATC-R = ADSL Terminal Unit- Remote
DSLAM = ADSL Access Multiplexer

**Figure 2a: ADSL Access (all-copper loops)**

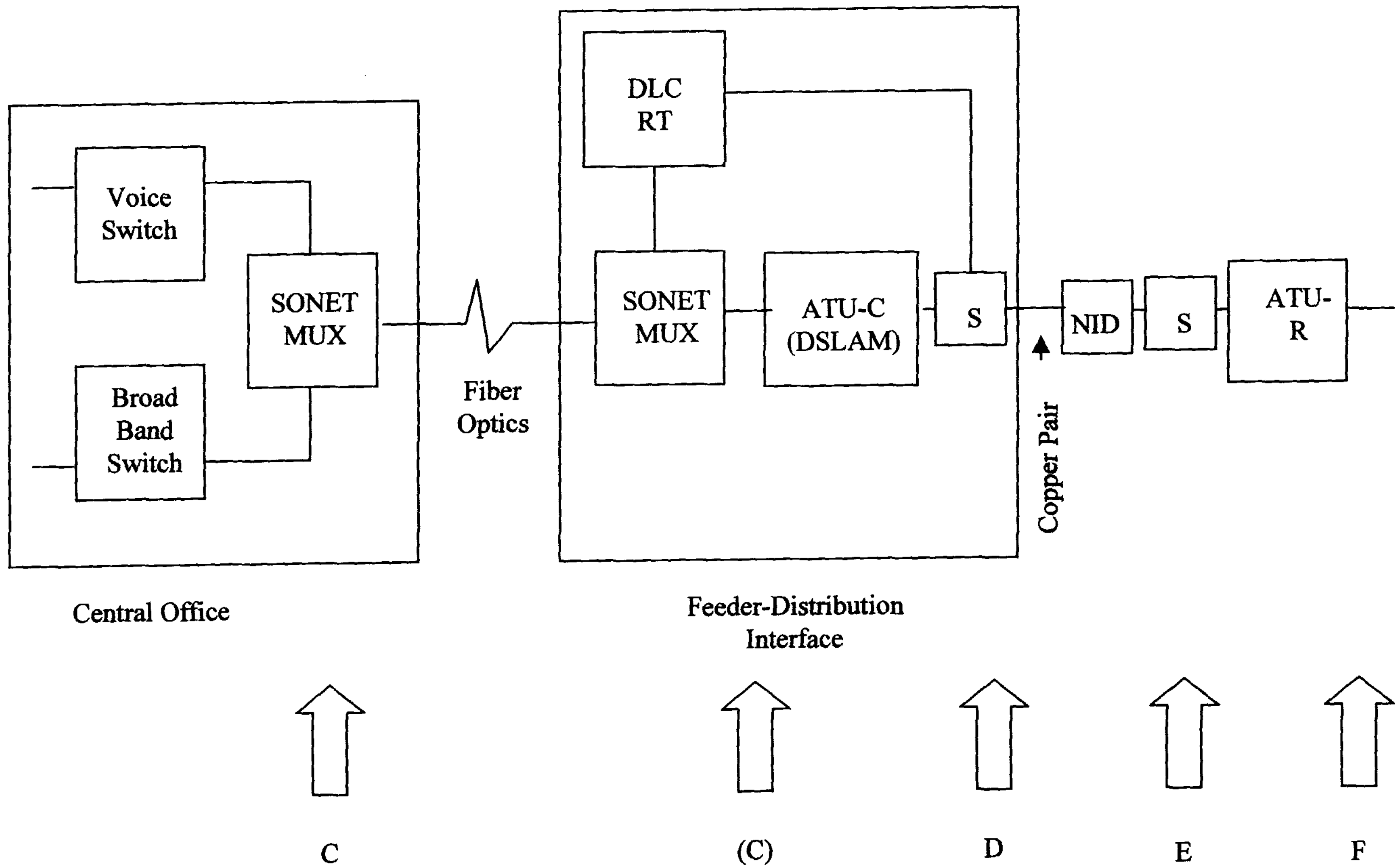



**Figure 2b: ADSL Access (Copper Pairs + DLC Loops)**

## APPENDIX
## BROADBAND TECHNOLOGY ISSUES

The purpose of this Appendix is to provide a detailed discussion of statements made in Section I in defining broadband services, and in Section V in presenting technical recommendations to the Commission.

### A. Ambiguities in the Definition of Broadband

The Commission's definition of broadband contains two ambiguities that are resolved in the definition this Report uses. First, the Commission refers to broadband as meaning "sufficient capacity – or `bandwidth' – to transport large amounts of information."[93] The drawback in this definition is that it should also contain at least some notion of the time required to transmit the "large amount of information" in question. What constitutes a reasonable amount of time is undoubtedly qualitative to some degree, and certainly depends on the application requiring the transport of the information. On the other hand, even existing narrowband services, such as the transmission of information using modems on voice circuits, can also transmit large amounts of information, given enough time. So without some notion of the time required, there is an insufficient distinction between narrowband and broadband; this is addressed in the Report's definition by specifying a minimum bit rate associated with broadband.

Second, the Order/NPRM refers to the "speed" of moving information across a network, but does not clarify what is meant by speed. Speed in this context really has two meanings. One meaning is the bit rate – the number of bits per second – at which data can be transmitted across a network or any link in that network. The higher the bit rate, the shorter the amount of time required to transmit a given unit of information. The other is the delay across the network – the length of time it takes for a given bit to get from the source to the destination. While one might assume that bits travel at the speed of light in the transmission medium, and that the only delay is the amount of time it takes to transmit a signal at the speed of light in the medium in question across the distances associated with the network,[94] in actuality a considerable additional delay is often incurred at points in the network where switching takes place and/or there is an information buffer between two links in the network that transmit information at a different bit rate. Thus delay is important as well. A source can transmit, and a destination receive, bits at a very high bit rate. But there could be inordinate transport delays, because some device within the network could require a long time to process and buffer bits for subsequent transmission over the next link in the network.

The two different meanings of speed are often combined into what is called the latency of the network. For a given amount of information to be sent, measured in terms of total bits or bytes, the latency of the network is defined as the time that elapses between the transmission of the first bit at the point of origin and the receipt of the last bit at the destination. In light of this discussion, the Report's definition of broadband captures the requirement of low latency by referring to both the minimum bit rate <u>and</u> the requirement that there be low delay across the network.

---

[93] Order/NPRM, footnote 4.

[94] For a terrestrial cross-country circuit 2,500 miles long, taking the speed of light to be about 2/3 of the speed of light in a vacuum, the pure transmission time is about 20 milliseconds. For a satellite in geosynchronous orbit, taking the speed of light to be approximately the speed in a vacuum, the "out and back" transmission time is about 250 milliseconds.

Low latency can be assured through 1) high bit rate transport over every link between a source and a destination; and 2) low-delay switching. The implication of the first requirement is that there must be high-bit-rate transmission over not only the "backbone" of the network that connects switches to each other (consisting of what are often called "inter-office facilities"), but also over the access links that connect the sources and destinations, or "end points," of communications to the rest of the network. This is another way of emphasizing what the Order/NPRM states, that "there must be a solution to the problem of the 'last mile.' No matter how fast the network is, if the connection between the network and the end-user is slow, then the end-user cannot take advantage of the network's high-speed capabilities."[95]

The requirement of low-delay switching poses an interesting dilemma. In a circuit switched network, the switches introduce almost no delay once a communications session is established.[96] On the other hand, one of the reasons for the popularity of packet switching in data communications has been that data communications is often "bursty" in nature. In technical terms, this means that the peak bit rate required is considerably higher than the average required bit rate; In lay terms, it means that there are periods of low or no activity interspersed with periods of much more intense activity during a communications session. For such communications, the use of circuit switching, in which both switching and transmission resources are devoted to a particular connection

[95] Order/NPRM, at para. 8.

[96] For short communications sessions, such as a Point of Sale transaction between a terminal and host computer to, for instance, authorize the use of a credit card, the time required to establish a connection can be far greater than the subsequent time required to transmit the request and response. One could add "short connection time" to the list of desirable attribute of advanced communications that is satisfied by packet switching.

during its entire duration, even when no information is being exchanged, represents an inefficient use of what may be an expensive resource. By contrast, in packet switching, many communications sessions share the same switching and transmission resources, over which information from the different sessions is interspersed. This makes more efficient use of the resources, but it comes at a price.

As the Order/NPRM notes, "packet switching breaks the information up into smaller packets that are transmitted separately over the most efficient route available, and then reassembled, microseconds later, at their destination."[97] The price implied by this description is that considerably more processing – forming packets at the sending end, interpreting the packet address information in each switch, routing packets over the best available route, reassembling the individual packets into the original stream of information at the destination, etc. – is required in a packet network. This extra processing introduces delay; it can also cause situations in which too many sessions have data to send at the same time, leading to substantial additional delay, or even the loss of packets, as data must be buffered for later transmission.[98] There is also an issue of transmission costs versus switch processing costs. As attested by the popularity of packet switching for data communications over the past four decades since packet switching was invented, however, the efficiency issue resolves in favor of extra processing.

Were the industry stuck with the earliest packet switching technologies, it would appear that there would be a "Hobson's choice" between the higher efficiency of packet switching and the network delay it introduces. Over the past few years, however, new

---

[97] Order/NPRM, at para. 6.

packet switching techniques have been developed that cause considerably less delay. These are commonly referred to as fast packet switching ("FPS") technologies; typically in FPS the speed is attained by doing more of the packet switching in hardware components of the switch, as opposed to processing by software characteristic of earlier packet switches. Of course, both software and hardware switching have benefited greatly by the rapid increases in processing and memory power of computers that have taken place since packet switching was first invented.

The Report assumes the use of FPS technologies in connection with broadband services in the near term. It is important to point out, however, that the tradeoff between the higher processing costs and the lower transmission costs associated with packet switching will continue to be reassessed as technology advances. Should the tradeoff turn in favor of circuit switching, this could at some point lead to a technology that might be referred to as "fast circuit switching," recognizing its likely ability to establish and terminate connections (switched circuits) much faster than the several seconds associated with circuit switches today. Such a change is entirely possible as the cost of bandwith – that is, of transmission – continues to drop in today's extremely high capacity and efficient backbone networks.

## B. Definition of Broadband Communications

For more than one hundred years, the telecommunications industry has been building the PSTN primarily to support voice calls. Originally, the switching and transmission facilities were based on analog communications. The transmission facilities

---

[98] In extreme cases, even buffers may overflow, causing data to be lost.

were defined in terms of their bandwidth, meaning the range of frequencies that could be transmitted over the facilities. Individual voice circuits were limited by analog electronics to a frequency range of 300 to 3,300 cycles per second, or Hertz ("Hz"), thus the bandwidth of a voice circuit was approximately 3,000 Hz. All practical transmission systems in that era used frequency division multiplexing, or "stacking" of multiple voice signals, into a higher bandwidth composite signal. The bandwidth of commonly-deployed transmission systems ranged from a few million Hertz ("MHz") to as high as a billion Hertz ("GHz"); these were referred to as broadband systems, but still organized the available spectrum to support individual voice circuits.

During the time in which voice communication was defined and supported in analog form, data communications signals generated by computers and other data devices, even though digital in nature, were converted by "modems" (modulators/demodulators) into analog signals suitable for transmission over the analog network. The data speeds supported by modems has grown steadily from a few hundred bits per second in the early 1980's to close to the theoretical limit of about 30 kilobits per second ("kbps") today. In addition, sophisticated data compression techniques have been incorporated into modems over the past few years, leading to a reduction in the number of bits required to adequately represent the information being conveyed, and thus to effective data rates as high as 56 kbps.

Starting in the early 1960's, telephone companies began to deploy digital transmission systems. To be carried on such systems, voice signals had to be "encoded" into a digital format for transmission over the digital facilities, and "decoded" at the receiving end before reaching the analog telephone receiver. The coding schemes employed at that time digitized voice into a 64 kbps signal.[99] As with analog transmission systems, practical digital transmission systems combined, or "time division multiplexed," multiple voice signals into higher-bit-rate composite signals. The composite digital rate on such systems has steadily grown from an original commonly-deployed rate of around one megabit per second ("Mbps") to today's high-end systems operating as high as 10 gigabits per second ("Gbps"). A digital hierarchy was defined, with various bit rates designated as DS-0 (64 kbps), DS-1 (approximately 1.5 Mbps), DS-3 (approximately 45 Mbps), and upward.

During the mid 1980's to early 1990's, a new family of transmission standards called the SONET[100] was developed and deployed. Transmission speeds in SONET are designated in multiples of the basic OC-1 rate of 51.84 Mbps; thus a high-end OC-192 system operates at 192 times the basic rate, or approximately 10 Gbps.

Notwithstanding the existence of digital transmission systems, a substantial amount of data communications is still done using analog modems. This leads to a situation in which the inherently-digital signals from data communicating devices are converted to analog form for transmission over the analog voice network, within which the analog signals may, within a very short distance of the originating premises, encounter a transmission system that converts them to digital form[101] for transmission across the entire network to a point near the destination premises, where they are

[99] Literally, the coding scheme used somewhat less than 64 kbps, but signaling and framing information took up the remainder.
[100] The international standard equivalent to SONET is the Synchronous Digital Hierarchy ("SDH").
[101] Not the same bit stream as the original bit stream output by the computer, however. Consistent with the way that analog signals are digitized, the bits within the network represent the height of the analog signal

converted back to analog form, sent the rest of the way to the premises, and then converted back to their original digital form by the modem to be received by the signal processing circuitry of the receiving computer.

But from the early days of digital transmission systems, such systems have also been used to support dedicated (that is, non-switched) digital circuits between two users' premises. Among other applications, such dedicated circuits support high-speed point-to-point digital communications, thus it is not accurate to think of the PSTN as providing only telephone service. On the other hand, the lack of switched digital communications has been an increasingly onerous limitation of the PSTN, as it is typically very expensive to satisfy the need for ubiquitous digital connections with dedicated circuits.

The term "bandwidth" was invented to describe the frequency range supported on an analog transmission system or circuit, and it only has literal significance when used in that fashion. Nevertheless, sometime during the first decade or so of digital transmission systems, it became common to also refer to the data rate on a digital transmission system as the "bandwidth." Today, bandwidth more commonly refers to the bit rate of digital transmission. Digital signals with rates at or below the DS-0 rate of 64 kbps are commonly referred to as "narrowband" signals. Digital signals with rates at and above the DS-1 rate of 1.5 Mbps are commonly called "broadband" signals. The area in between was, in times past, often referred to as "wideband," but this term is not common today. As ILECs have begun to deploy xDSL systems, which in the case of ADSL, provide signals to subscribers at rates as low as 256 kbps, they have tended to refer to

---

that is generated by the modem at different instants of time, not the original digital content of the signal these as broadband system. Therefore, we will use the term "broadband" to refer to digital rates of at least 256 kbps,[102] and again add that the current interest in broadband communications is focused on switched broadband services, not dedicated circuits, and on high-speed circuits where the available bit rate is used as a unit, rather than being organized into 64 kbps digital voice "channels."

## C. Definition of the Local Exchange Applicable to Broadband Services

This section attempts to differentiate between local exchange and long distance networks in a way that is applicable to broadband services. In the case of voice communications, tariffs typically define a local exchange calling area within which calls are classified as local and are charged on either a flat-rate or message unit basis. Calls between such local exchange areas are classified as toll or inter-LATA calls, depending on whether or not they cross one of the LATA boundaries defined by the MFJ agreements. In either case, inter-exchange calls may be classified loosely as "long distance" calls. Therefore, there is a reasonably well understood distinction between local and long distance calling, although the distinction is highly jurisdiction-specific.[103] On this basis, the local exchange network comprises the facilities that support local calls and access to long distance networks, whereas long distance networks comprise the facilities that support long distance calls. The boundary between the two can be thought

---

input to the modem.

[102] This definition excludes the basic rate interface ("BRI") of the Integrated Services Digital Network ("ISDN"), which operates at an aggregate user bit rate of 144 kbps. This is appropriate in any case, because the BRI bit stream is organized into two DS-0 signals and a 16 kbps signal, all of which are narrowband. In fact, even though there are other ISDN interfaces operating in excess of the minimum rate we have defined as broadband, those should be considered to be narrowband if they organize the bit stream into DS-0 channels.

of as passing through transmission facilities that connect two local exchange networks together, if local and toll calls are provided by the same entity, or through the so-called POP of the long distance provider located in each local exchange area.

However, the local versus long distance distinction is not always so clear in the case of broadband data communications, because 1) tariffs, if they exist at all, are still typically in a formative state, so there is not as much precedent for distinguishing local, toll, and long distance calls; and 2) some entities now, and possibly more entities in the future, will provide both local and long distance services. What helps somewhat with this differentiation, though, is that interoffice facilities will normally be provided on fiber rings, and the rings that interconnect switches in an exchange area to support exchange area services will generally be distinct from those that support services over longer distances. Even if this is not the case, we will depict the BLEN as having interoffice rings, and simply beg the issue of whether the far extent of such rings are still within the local area.

## D. Components of the Broadband Local Exchange Network

### 1. Broadband Premises Networks and Devices

The Report does not deal at length with the nature of the customer equipment that is communicating over the BLEN. However, for completeness, this section provides a very high-level overview of what may become a vast array of different kinds of broadband premises networks and equipment.

---

[103] For instance, in some states, the boundary circumference of one local exchange area may be many tens to hundreds of miles; in other states, a local exchange area may encompass one or a few small communities of very small geographic extent.

Behind whatever broadband network interface and access termination device that terminate the BLEN at the entry to a customer's premises, there is at least one device, and possibly many devices, that communicate over the BLEN in the process of supporting broadband applications. There may even be narrowband devices, such as the telephone, that are adapted to the BLEN for the sake of whatever efficiency gains may result from integrating all forms of communications on a single network. For instance, there is presently a great deal of interest in the subject of telephony over the internet, often referred to as "voice over IP," in which voice signals are digitized and turned into internet packets for transmission across the internet.

In the case of a residence or small business, the broadband device at present is most likely to be a PC equipped for high-speed communications.. In the future, it might be a communications "integrator" that consolidates all communications to/from a variety of broadband devices within the premises. In this case, any or all of PCs, workstations, digital televisions, videoconference units, and the like may connect to the communications integrator, whose role is to combine the individual bit streams from the devices and transmits them as a single bit stream across the BLEN, while doing the reverse with the incoming integrated signal.

In the case of a large business, the entry device is likely to be either an internet router or other premises switch that communicates with various premises devices via a local area network ("LAN"). Whatever the customer premises arrangement, the key point is that something, or some things together, use the BLEN to transmit and receive a broadband bit stream in the process of supporting customers' broadband applications.